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AN INDUSTRIAL IOT IN ENGINEERING AND MANUFACTURING INDUSTRIES – BENEFITS AND CHALLENGES

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ABSTRACT

Industry 4.0 is the promising area of the industrial revolution and fast-growing network of digitally connected smart devices, equipment/machines and physical objects. It denotes the use of Industrial Internet of Things (IIoT) in manufacturing. Industrialists and Manufacturers are already taking part in this transformation by integrating both new and existing Information and Operational Technologies (IT & OT). IIoT is fairly a new concept for industries, and it is presenting a huge opportunity in helping enterprises to operate more safely and productively while improving efficiency and reducing costs. The study was conducted to explore the benefits of IIoT in engineering and manufacturing industries, to analyse the various challenges on IIoT and to identify the ways to overcome the challenges of IIoT. This paper analyses how IIoT strategy facilitates to increase customer value, creates different opportunities for competitive advantage, and transform the business process to increase profit in industries. Secondary data was collected from web sources and journals to identify the benefits and challenges on the implementation of IIoT. Interviews with industry experts were conducted during October 2018 to obtain their opinion towards employment of IoT and IIoT technology in the engineering industries. As this paper concentrates only on bringing out the possibilities of implementing IIoT in engineering and manufacturing industries, this study is basically done as an exploratory research.

KEYWORDS: Benefits, Challenges, Engineering, Internet of Things, Industrial Internet of Things, IoT, IIoT, Industry Revolution, I4.0, Manufacturing & Technology

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INTRODUCTION

Traditional businesses in India are being disrupted with the advent of new digital technologies viz. mobile device technologies, cyber security, social media, cloud, analytics, machine learning, internet of things and connecting legacy system through integration platforms. This transformation has given ample opportunities to redefine the way engineering and manufacturing is run today (Rekha Kodali, 2018). These businesses are expected to spend 80 per cent of their incremental expenses on technology and it is estimated to grow to almost $4 trillion in total addressable technology market by 2025 (Nasscom, 2018). Every human being on earth is expected up to six devices (excluding computer system and mobile phone) will be connected to the internet which links all aspects of the physical world by 2025. This scenario generates more demand for IoT enabled products and equipments. Establishing IIoT framework and producing IoT enabled devices to meet out this demand is a big task for many engineering and manufacturing industries. IIoT (Industrial Internet of Things) is an emerging technology for the manufacturing industry, which provides an opportunity to operate more safely and productively in an organisation. Toya Peterson (2016) stated that “the entire maturity cycle from smart sensors and gateways to cloud analytics in

manufacturing space are using its solutions that cater to the diverse needs of customers across the world". IIoT provides a number of ways that can extend manufacturing and engineering to bring them fully to make industry for the future. Manufacturers and industrialists in every sector have a significant opportunity at hand where they can not only monitor, but also automate many of the complex process involved in manufacturing. IIoT technology provides complex details to the manufacturers which could not be made available with ease in the legacy systems.

REVIEW OF LITERATURE

A recent executive survey conducted by Forbes Insights found that the biggest challenge in building out IoT capabilities is the quality of IoT technology. Many companies are facing problems with the adoption of industrial IoT during identification of automated process for achieving highest effectiveness (Raj Ven, 2018). Adopting IoT technology in the manufacturing industry is one of the shot ways for getting competitive advantages and it helps to create enterprise value in the process (Toya Peterson, 2016). Press release of IoT Analytics (2018) said that the 4th industrial revolution(I4.0) employs a combination of multiple technologies that manufacturers are implementing to realize key use cases for improving efficiencies, generating revenues and reducing risks. The product and service market of I4.0 is predicted to grow to $310 billion by 2023. As per the survey conducted by the Accenture, Business insider & SAP (2015) of 1400 owners of business, 60 percent of the global manufacturers will use connected devices to analyse and optimize processes, 36 per cent of the business leaders understand IIoT, out of this, only seven per cent are able to implement it. Also it is found that $70 billion would be capitalised by manufacturers in IIoT by 2020 and product development and assembly costs can be reduced to 50 per cent.

OBJECTIVES

Industry 4.0 is the emerging trend of the industrial revolution and fast-growing network of increasingly smart connected devices, equipment/machines and physical objects (Paul Daugherty, 2015). It denotes the use of Industrial Internet of Things (IIoT) in manufacturing. IIoT emphases on the use of cyber-physical systems to monitor the physical factory processes and make data-based automated decisions. The aim of this article is to provide information to the company executives in the manufacturing industry about the possible use of Industrial IoT and the way it influences the process and operation. The study was conducted with the following objectives.

- To study the benefits of IIoT in engineering and manufacturing industries.
- To analyse the various challenges on IIoT
- To identify the ways to overcome the challenges of IIoT

RESEARCH METHODOLOGY

IIoT is in the middle of a massive transformation of engineering and manufacturing industries. Jeffrey Lee (2017) estimated that the number of connected devices grow to 20 billion in 2020 from 8 billion in 2017. This new model of connected devices helps to create innovative business models such as automated real-time decision making or products-as-a-service. At present, manufacturing companies need an IoT strategy to success in the competition market (https://iot-analytics.com/product/white-paper-iot-strategy-primer/). This paper analyses how IIoT strategy facilitates to increase customer value, creates different opportunities for competitive advantage, and transform the business process to increase profit in industries. In order to achieve the objectives of the study, secondary data were collected from web

sources and journals to identify the benefits and challenges on implementation of IIoT in the engineering and manufacturing sectors. Interviews with industry experts were conducted during October 2018 to identify their opinions towards employment of IoT and IIoT technology in the engineering industries. As this paper concentrates only on bringing out the possibilities of implementing IIoT in engineering and manufacturing industries, this study is basically done as an exploratory research.

IoT Vs IIoT

Internet of Things (IoT) is an emerging trend and now it is one of the key elements of Digital Transformation drive the world in various ways. IoT (Internet of Things) and IIoT (Industrial Internet of Things) are exactly the same thing (Jeffrey Lee, 2017) but it has a least difference in coverage of its operation. IoT can be used for industrial, manufacturing, and agricultural applications whereas IIoT emphases on improving connectivity between devices, saving time, efficiency optimization, and other possible benefits. It plays a significant role in day-to-day impact on businesses and its safety. The term “IoT” includes all functionalities of IIoT and in addition consumer use-cases such as smart home technologies and wearables for IoT. The focus of IoT is ‘consumer perspective’. It uses in smart home appliances and house automation projects. Amazon Alexa, an IoT-enabled device control everything in house from locking doors, changing the temperature, lights on or off with voice commands etc. Some of the examples for smart home automation projects are Mailbox 2.0, an IoT enabled mailbox that provides real-time notification for when letters and packages arrive; Holocron Lamp rises up and gives you light when we wave hand; A Wi-Fi security camera that takes pictures and streams video to a web application; A Fitbit device for wearable device; Apple’s smartwatch connect internet, communicate to phone and send messages to other devices; Lobot 2.0 a wearable Headgear for communication with web page; Mango, a wearable device for the visually impaired for obstacle-detection and GPS navigation; Mimo Baby Monitor: The Mimo Baby Monitor monitors the baby's respiration and sent the information to the parent's smartphones. IIoT focus workers safety, productivity and monitors activities and conditions with remote control functions ability such as oil pipelines monitored by drones, chemical factories, excavators, drilling equipment monitored by sensors, developing smart cities with mix of commercial and IIoT (Sandeep Raut, 2017).

IIoT is the sub category of IoT. IIoT is the use of IoT technologies in manufacturing and industrial sector. In manufacturing and production, IIoT incorporates the technologies such as machine learning, big data, sensor data harnessing, automation and machine-to-machine (M2M) communication. The primary thought behind the IIoT is that smart machines are better than humans at accurately, consistently capturing and communicating data. Further, these data can be used for empowering organizations to complete the task in lesser time, solve the problems, save money and support business intelligence efforts. Sandeep Raut (2017) specified the difference between CIoT and IIoT that if home appliance refrigerator is connected to the Internet is called as Consumer IoT (CIoT) whereas, the manufacturing/automobile/factory equipment have sensors connected to the internet is called as Industrial IoT (IIoT). In manufacturing specifically, IIoT holds great potential for creating eco-system, quality control, sustainable and green practices, supply chain management and overall efficiency. IIoT facilitates the operational environments of the industry in two ways: i) it integrates smart connected machines and manufacturing assets with the widespread enterprise which help to create more efficient and flexible environmentii) improving asset performance through the positioning of cost effective wireless sensors, easy cloud connectivity and data analytics. Data are gathered from different field and converted into actionable information in real time resulting in improved business processes.

Companies like Particle offer a fully-integrated IoT platform that provides everything such as necessary hardware, software and cloud infrastructure to the client need to deploy an IoT product. Particle devices are connected to the Particle device cloud which provides scalable and reliable gateway between the client's devices and the web. In October 2018, the company has introduced the next generation IoT products such as IoT Rules Engine - a drag-and-drop IoT application builder to accelerate the time to market; Workbench (Developer Preview), a free, all-in-one offering to develop, program, and debug professional-grade apps for the Particle platform; Mesh SOMs (System on Modules), an enterprise-grade, production-scale version of Particle Mesh (Source: https://www.particle.io/.) This allows consumers to add IIoT like capabilities to their home automation projects.

Industrial Internet of Things (IIoT) is a rapidly progressing sector accounting for the maximum share in the global IoT spending (Newgenapps, 2017). According to International Data Corporation (IDC), USA and Systems Applications and Products (SAP) in 2017, sixty per cent of manufacturers at global level will use analytics data tracked using connected devices to examine processes and ascertain optimization possibilities. Figure 1 shows the spending on Internet of Things at global level in 2015 and 2020.

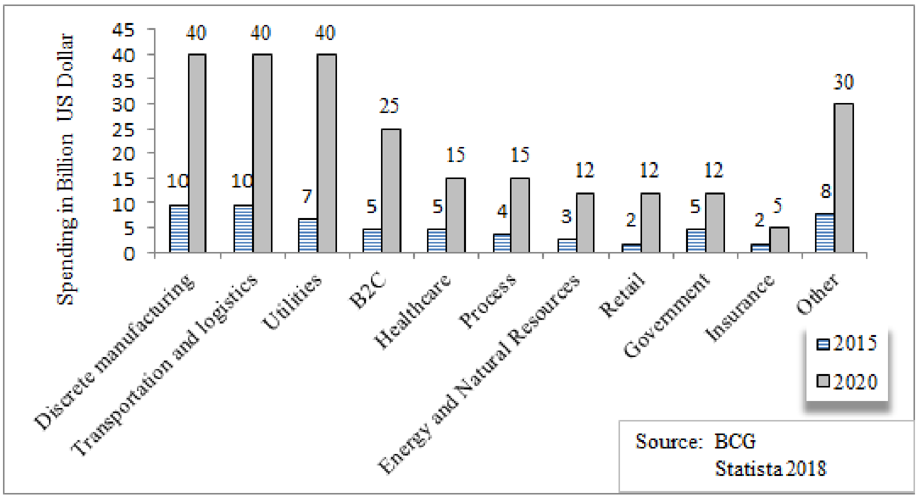


Figure 1: Spending on IoT at Global Level

BENEFITS OF IIoT IN MANUFACTURING

The usage of IIoT in engineering and manufacturing sector is inevitable in the near future. Companies are starting to use IIoT provides an unprecedented level of visibility throughout the supply chain. IoT embedded devices and software to manage their vehicle fleets, keep track their vehicles, and correct their paths if it goes to the wrong direction. Using IoT to track "things" on the field is called as 'asset tracking', where the companies are allowed to track and manage their inventory. In other words, it can be used to track more vehicles and monitor raw materials or containers in a warehouse. IIoT helps to 'predict maintenance and analyse' the situation when equipment is about to fail. Sensors notification will be sent out to maintenance teams if a problem arises or the equipment reaches its expiry date. This system helps the organiser to find how often these notification failures happened, create maintenance timelines, service the equipment before it fails. IIoT enables new sources of customer value. Most of the value stands in powerful analytics and cross-ecosystem collaboration. It leads to long-term advantage over the competition through several sources viz. unique data sets, superior algorithms and exclusive partnerships. The following are the benefits of IIoT in engineering and manufacturing industries.

- **Digitally Connected and Remote Management:** IoT enabled tools and machines digitally connect the partners like user, equipment manufacturers and field engineers that can transmit operational information and commands. This will help the managers and process heads to identify the key result areas and remotely manage the factory units to take advantage of process automation and optimization.
- **Facility Management:** The application of IoT sensors in manufacturing equipment/machines enables condition-based repair and maintenance alerts. Many critical machine tools in a factory are designed to function within temperature constraint and vibration ranges. IIoT sensors can monitor these machines and communicate the alert message when the machine/equipment deviates from its prescribed parameters. Using this alert data, manufacturers can preserve energy, reduce costs also increase operational efficiency.
- **Auto Supervision:** IIoT helps to monitor the production flow activities starting from the refining process to the packaging of final products reach to consumers. This real-time monitoring process provides better management of operational cost and thus eliminating wastes and unnecessary work in progress inventory. IIoT supports 'auto-supervise' the activities known as 'process2device'. Workers can transfer the workload to the machine devices which are embedded with sensors and actuators helps to auto-supervise internal and external processes.
- **Real-Time Asset and Inventory Management:** IIoT sensors help to locate and monitor key assets, track and trace the inventory, events across the supply chain and the clients are informed of any significant deviations from the plans. Digitization has opened up untapped areas to optimize production costs and agility by giving a complete view of logistics, inventory levels, market demand, etc. (Rekha Kodali, 2018). IIoT applications provides cross-channel visibility into inventories, so that the realistic estimates of the available material, arrival time of new material and work in progress can be performed by the managers. This process helps to optimizes supply and reduces shared costs in the value chain.
- **Plant Safety and Security:** IoT enables workers to communicate with machines and IoT device apps and monitors the Key Performance Indicators of health and safety, providing a real-time view of the on-going activities, property damage or loss during operation time, the number of injuries and illness rates, near-failures, absences in different terms, vehicle incidents etc. Such communication helps in predicting mishaps and responding to emergencies in time (Toya Peterson, 2016). IIoT associated big data analysis helps to improve the overall personnel's safety, health, and security in the factory.
- **Quality Control:** IIoT enables the manufacturers to collect aggregate product data relates to raw materials used and its composition, heat and temperature in the factory field, working environment, waste management, transmit of products and its impact, customer feeling on using theproduct etc. on the final products. These data can be utilized for solving various quality related issues and correct them.
- **Reduced Downtime:** IIoT enables the operation managers to monitory entire real-time manufacturing process, allowing them to assess the quality and efficiency of each machine and equipment, ultimately reducing downtime.
- **Manufacturing Insight and Packaging Optimization:** IoT sensors in products/packaging help the manufacturers can gain insights into the usage patterns, product handling of multiple customers, trace product deterioration during transit, impact of weather, road and other environment variables on the product. The sensor data helps the manufacturer to improve their performance in packaging and customer experience. IoT assists

manufacturers to connect machines and control systems together, allowing them to get deep insight into the manufacturing process (Toya Peterson, 2016).

- **Data Analysis**: Data are always collected from all the machinery through the IoT sensor device, it can be further analysed using Big Data for significant and effective decision making.
- **Proactive Maintenance:** Continuous assessment of machine operation and its devices becomes easy with it. It helps manufacturers determine the time to repair and take proactive maintenance to ensure seamless production.
- **Return on Investment:** IoT has great potential to augment the production process and to step the industry to the next level of success in manufacturing. IoT enables the manufacturer to generate significant business value through innovation and provide scope for high return on investment (ROI) by connecting an increasing number of devices, machinery and/or equipment in an intelligent network.
- **Logistics and Supply Chain Optimization:** IIoT can provide access to real-time supply chain information. Materials, equipment, and products are easily tracked as they move through the supply chain. Vehicles, containers, pallets, cases and even different items can be furnished with auto identification tags and tied to GPS-enabled connections to continuously update location and movement (Sandeep Raut, 2017). All the parties connected with supply chain can trace interdependencies, material movement and manufacturing cycle time. This will facilitate on-time delivery report to manufacturer, reducing the potential capital expenditure and cost of inventory (Marlon Luz, 2014).
- **Integrated Operations Dashboard:** Different silos of manufacturing, supplier, and logistics operational data can be grouped using contextualized key performance indicators (KPIs) into unified, real-time dashboards that will ultimately support companies to make faster and better decisions, identify problems more quickly and improve performance(RekhaKodali, 2018).
- **Scalable IoT Operations Management:** Emergence of numerous IoT solutions in the engineering and manufacturing industry have opened up a requirement for information technology developer teams to provide special focus in creating a highly scalable system for employing large number of products, big data, and operating in an heterogeneous environment. It also enables to develop rapid IoT application for getting competitive advantage in the engineering industry.
- **Perform better Data Analytics**: An outpouring amount of data is being generated with connected devices, sensors, and business systems, that helps in manufacturing insights, optimizing business processes and realising innovative opportunities. IoT Hub is used to manage the two-way communication between the cloud and devices. Advanced analytics is applied on data collected to disclose new business insights and these are converted into action through intelligent applications viz. Cortana, machine learning, Power BI etc. Finally the output of analytics is stored in software like Azure Tables, Azure SQL, Azure Blobs, HD Insight, Azure Data Lake etc. (Rekha Kodali, 2018). The various uses of IIoT in manufacturing fields are listed in Figure 2.

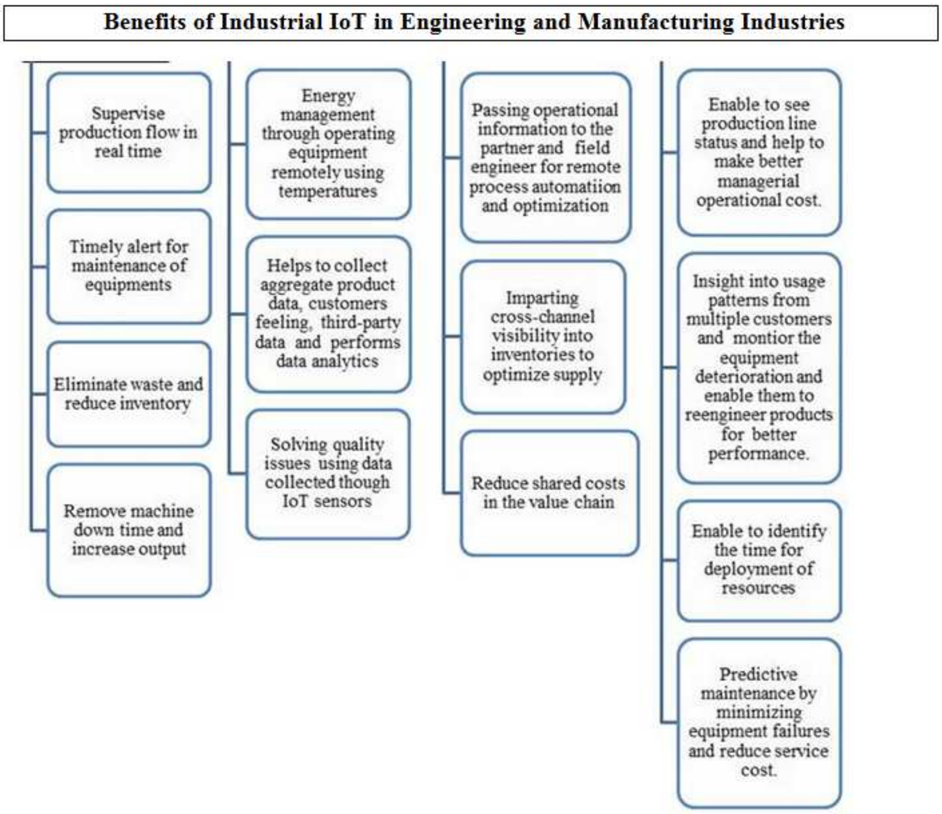


Figure 2: Uses of Industrial IoT

The term Industry 4.0 has become a global term to describe the fourth industrial revolution. Industrialists and Manufacturers are already taking part in this revolution by integrating both new and existing Information Technology (IT) and Operational Technologies (OT) and realizing key use cases such as advanced digital product engineering, augmented operations, data-driven inventory optimization, human-robot collaboration, predictive or proactive maintenance, everything-as-a-service business models, additive production, data-driven quality control, remote asset testing and remote service that are improving efficiencies, creating new revenue streams, and reducing risks (IoT Analytics, 2018). One of the key elements of I4.0 is supporting technologies such as additive manufacturing, drones, augmented and virtual reality, collaborative robotics and connected machine vision. While implementing these technologies in industries, engineers and industrialists are facing many challenges and these are described below.

- **Security Issues**: Security issue is the primary challenge on IIoT technologies. Dr. Irene Petrick, Director of Industrial Innovation, Intel's IoT group stated that rapid growth in smart technologies such as connected machines, globalised computer technologies, robots, smart devices and real-time data analytics in the larger manufacturing system expected from IIoT need to address potential challenges and the security issues in implementation. Non-existence of comprehensive cyber security solutions is the main challenge of large scale engineering industries. The biggest concern as the violations affects individuals as well as company susceptible to financial and operational risks. As engineering and manufacturing sectors using a variety of IIoT solutions, they are open to security concerns, cyber risks associated with information technology and operational technology convergence, and insider threats. Appling IIoT technology will be challenged until it has a concrete security feature.

- **IIoT Integration**: Integrating information technology (IT) and operational technology (OT) is another critical challenge faced by the companies during Industrial IoT implementation. Atmost care should be taken while integrating these technologies and ensure that the data are communicated without any loss and vulnerability. IIoT integration require huge amount for implementation and logistically unpractical for several operational businesses. Normally IoT devices are developed as independent solutions and it is adopted into the engineering and manufacturing process to become a part of the whole system. However, integration of IT and OT lacks effective connectivity and synchronization.

- **Connectivity and Visibility:** Another complicated challenge during implementation of IIoT is the lack of connectivity between different components and machine management. Frequent troubles are incurred in synchronizing as a result of internet outages, power loss, manual and technical errors. This will cause in the removal of connected devices from the digital network, affects the entire production process and require extra cost in damages. It is necessary to inspect connected machines and equipment in real time and engineers should ensure that those machines are working with optimum production capacity. Monitoring the life of the machines and insight into it is also critical in order to find out anomalies and solve the issues before they occur. IIoT will add additional challenges as you scale it universally.

Overcome the Challenges of Industrial IOT

Engineering and manufacturing companies facing IIoT challenges today may seem overwhelming. Implementation of quality of IoT technology, investment of huge amount in industry infrastructure and IIoT framework can be the solution for the challenges of IIoT and thus provide a new opening for business to increase productivity and growth for those industries. Joseph Zulick (2018) depicts that "Industries that hold a systematic approach of employing contemporary intelligent data management and analytics systems will get more worth with IIoT. In the revolution of I4.0, embedding IoT sensors in a new and legacy machines/equipment using in factories connected by an IP address, deliver alert messages to the decision makers". At present, engineers and designers are facing a challenge with a new task that how to identify value and communicate the benefits of IIoT technology adoption for consumers and companies. The following are the various viewpoints to overcome the challenges of IIoT by the manufacturers.

- **Decentralization of Activities:** During transformation of traditional system to new IIoT system, many tasks like service delivery, handling production, fulfilment and maintenance of equipment are the additional work of machine devices. It will become the task of engineers to spend time for calculating, analyzing, and inspecting how IoT devices can be integrated to make free time available for other tasks. Decentralisation of management enables manufacturers to overcome the challenges of IIoT. Activities like developing program scripts for preventing damages, replacing the machines, creating architectures and user-friendly interfaces can also be concentrated during decentralisation process.

- **Industrial IoT Gateway:** Integration of IoT gateway with the existing infrastructure of the company is one of the solution to meet the challenge of IIoT. It provides a secure connection to any industrial infrastructure and helps to solve the issues of interoperability and communication with machine-to-machine. For example, Mayuri Patel (2017) stated that "Industrial IoT gateway can connect the industrial Supervisory Control and Data Acquisition(SCADA)/Distributed Control Systems (DCS) directly with the Cloud using industrial serial

communication protocols such as MODBUS, International Society of Automation (ISA) Wireless Technology, Open Platform Communication (OPC), Process Field Bus (PROFIBUS) for edge to gateway connectivity and most promising many-to-many IoT protocol 'Message Queue Telemetry Transport (MQTT)' and one-to-one IoT protocol 'Constrained Application Protocol (CoAP)' for gateway to cloud connectivity"

- **Edge Computing Market:** Edge computing performs the computation function on distributed device nodes known as smart or edge devices (Rohan Shrama, 2017). It helps to reduce transmission costs, reduce latency, faster fault response time and increase user experience by transferring data at the edge of networks. Edge computing helps to transfer the data quickly and performs real-time data analysis. Boosting the 'edge' computing market is a modern trend which solves the problem of IIoT challenges through real time reporting. It transfers relevant data instead of sending bulk data on the cloud. During this computing process, cluster of gateways is formed through the connection of a number of gateways, which lead to distributed edge computing.
- **Implementation of Perception, Terminal and Network Module:** Manufacturers can resolve security issues by implementing 'Trusted Perception, Network and Terminal Module'. Rohan Shrama, 2017 said that encrypted data can be transferred by using"data-centric security solutions"viz. web application firewall, secure web gateway and application delivery controller etc.
- **Clustering of IoT Gateway:** IoT Gateway clustering helps to solve the problems occurred during the integrations of IT systems (ERP and CRM) with OT systems (SCADA and MES) and guarantee the continuity of cloud communication and data storage.

CONCLUSIONS

Automation of engineering and manufacturing industry creates a new evolutionary breakthrough with the service of Internet of Things. Though IIoT benefits through various ways, the manufacturers are facing many challenges while implementing it in their industries. This explorative study will be helpful to the manufacturers to understand about the challenges of IIoT implementation and provide them solutions to overcome it. In order to gain competitive advantage in the market, manufacturers should take the necessary initiative to differentiate their products in the market and perform adequate steps to meet price wars. At the same time, producing quality goods using Industrial IoT technology is also mandatory in the Industry revolution 4.0. This study will provide the scope for further studies in the areas like the challenges faced by the IIoT service providers, identification of problems faced by the company personnels during the implementation of Industrial IoT in their industries and the study of efficiency level in production after the implementation of IIoT.

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